MULTIMEDIA UNIVERSITY

STUDENT ID NO

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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

PME0016 MECHANICS

(Foundation in Engineering)

1 MARCH 2019
3.00 P.M. – 5.00 P.M.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 8 pages, including the cover page.
2. . Answer all questions.
3. Write your answers in the Answer Booklet provided.
4. Show all relevant steps to obtain maximum marks.

QUESTION 1 (10 MARKS)

a) **Figure Q1(a)** shows a ladder leaning against a wall. Suppose a person is climbing a uniform ladder that is 5.0 m long and weighs 180 N. The person who weighs 800 N, stops a third of the way up the ladder. The bottom of the ladder rests on a horizontal stone ledge and leans across the castle's moat in equilibrium against a vertical wall that is frictionless because of thick layer of moss. The ladder makes an angle of 53° with the horizontal, conveniently forming a 3-4-5 right triangle.

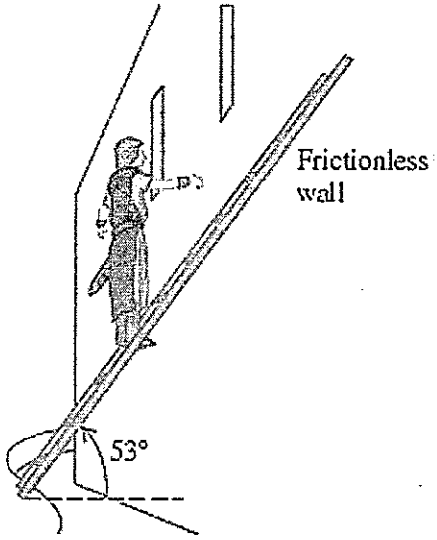

Figure Q1(a)

(i) Sketch a free-body-diagram for the ladder.

[2.5 marks]

(ii) Find the normal and friction forces on the ladder at its base.

[2.5 marks]

(iii) Find the minimum coefficient of static friction needed to prevent slipping.

[1.5 marks]

(iv) Find the magnitude and direction of the contact force on the ladder at the base.

[2 marks]

b) Could a ladder on a level floor lean against a wall in static equilibrium if there was no friction? Explain.

[1.5 marks]

Continued...

QUESTION 2 (10 MARKS)

a) Three identical boxes are pushed to the right a distance d across a rough horizontal surface as in **Figure Q2(a)**. All three boxes are pushed by constant forces that have a magnitude of F. The force pushing the first box is directed at an angle θ below the horizontal, the force pushing the second box is horizontal, and the force pushing the third is directed at angle θ below the horizontal. Rank the work W done by the force F on each of the three boxes, from the most work to the least. Explain your answer.

[3.5 marks]

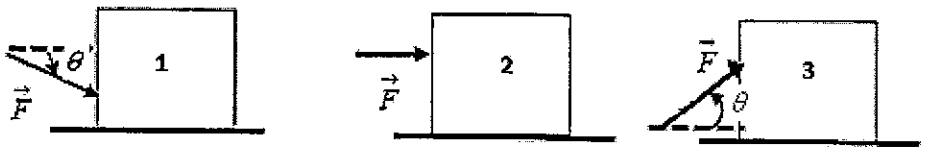

Figure Q2(a)

b) A tractor is hitched to a sled loaded with firewood and pulls the sled a distance of 20.0 m along level frozen ground. **Figure Q2(b)** shows the free-body-diagram of sled. The total weight of the sled and load is 14 700 N. The tractor exerts a constant force the F_T with magnitude 5000 N at an angle of $\theta = 36.9°$ above the horizontal. A constant 3500 N friction force opposes the motion. Find the work done on the sled by each force individually and the total work done on the sled by all the forces.

[5 marks]

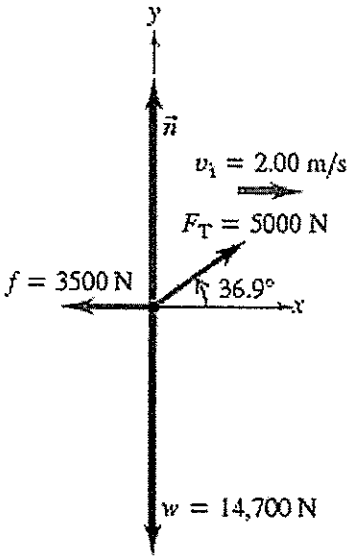

Figure Q2(b)

Continued...

c) A package with mass m is unloaded from a truck with an inclined ramp as shown in **Figure Q2(c)**. The package travelled with a displacement d from the truck to the floor. The ramp has rollers that eliminate friction, and the package is unloaded from an initial height h. The ramp is inclined at an angle β. Find an algebraic expression in terms of these quantities for the total work done by all of the forces on the package during its trip down the ramp.

[1.5 marks]

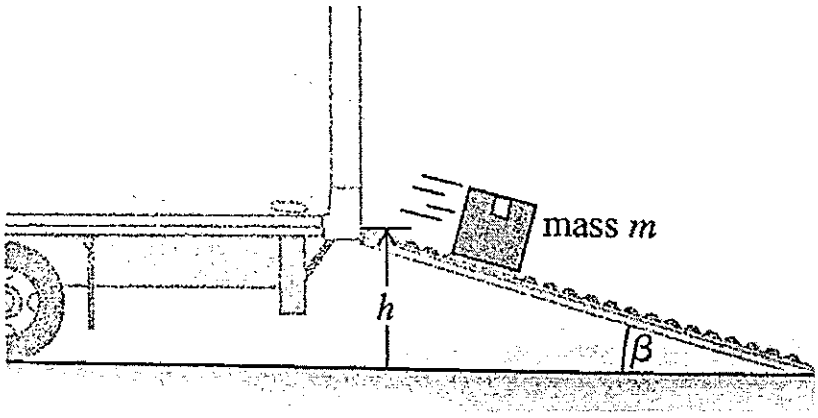

Figure Q2(c)

QUESTION 3 (10 MARKS)

a) A boy and a girl ride a turning merry-go-round. The boy is at the outer edge; the girl is near the axis of rotation. Which of them will have greater angular velocities? Based on the definition of angular velocity, give a reason for your answer.

[2 marks]

b) To play music, a compact disc (CD) must rotate at high speed while a laser reads data encoded in a spiral pattern on the disc. The disc has radius $R = 6.0\,\text{cm}$; when data are being read, it spins at 7200 rev/min.

(i) What is the CD's angular velocity ω in radians per second?

[1 mark]

(ii) How much time is required for it to rotate through $90°$?

[1.5 marks]

(iii) If it starts from rest and reaches full speed in 4.0 s, what is its average angular acceleration?

[1.5 marks]

Continued...

c) The angular velocity of the rear wheel of a stationary exercise bike is 4.00 rad/s at time $t = 0$ s, and its angular acceleration is constant and equal to 2.00 rad/s^2. A particular spoke coincides with the positive - x axis at time $t = 0$ s.

(i) What angle does this spoke make with the positive - x axis at time $t = 3.00$ s? Express the answer in degrees.

[3 marks]

(ii) What is the wheel's angular velocity at this time?

[1 mark]

QUESTION 4 (10 MARKS)

a) (i) The barometer in **Figure Q4(a)** contains two liquids A and B that differ in density. Write the formula for the pressure measured by the barometer, in terms of h_A, h_B, g (gravitational acceleration, ρ_A (density of fluid A), and ρ_B (density of fluid B) . Write a brief explanation to your answer.

[2 marks]

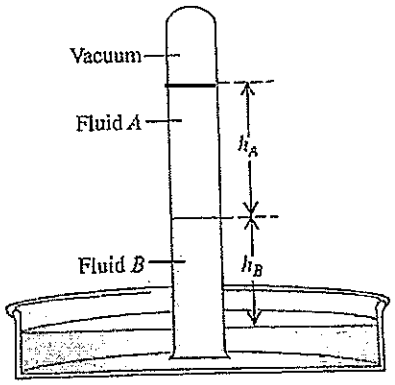

Figure Q4(a)

(ii) Compute the atmospheric pressure P_{atm} on a day when the height of mercury in a barometer is 76.0 cm. State your answer in the unit of atm.
($\rho_{mercury}$ = 13.6 x 10^3 kg/m^3).

[1.5 mark]

b) A 15.0 kg solid gold statue is being raised from a sunken treasure ship.

(i) State the principle of Archimedes.

[1 mark]

(ii) Find the tension in the hoisting cable when the statue is completely immersed.

[4 marks]

(iii) Find the tension when the statue is completely out of water.

[1.5 marks]

(ρ_{gold} = 1.93 x 10^3 kg/m^3, ρ_{water} = 1.00 x 10^3 kg/m^3)

Continued...

QUESTION 5 (10 MARKS)

A spring is mounted horizontally on an air track, shown in **Figure Q5(a)** and **Q5(b)**, with the left end held stationary. A spring balance is attached to the free end of the spring, and then being pulled toward the right, and the elongation is measured. It is found that the stretching force is proportional to the displacement and that a force of 6.0 N causes an elongation of 0.030 m. The spring balance is then removed and a 0.50 kg object is attach to the end. The object is then being pulled at a distance of 0.040 m, and when release, oscillations that obey simple harmonic motion is observed. Find the

(i) spring constant of the spring.

[1.5 marks]

(ii) maximum and minimum speed attained by the vibrating object. State the position when will the maximum and minimum speed can be observed during the oscillation. Given that the value of frequency for this motion is 2 Hz.

[2.5 marks]

(iii) maximum and minimum accelerations, of the vibrating object.

[2.5 marks]

(iv) kinetic energy, and elastic potential energy of the system when $x = 0.020\,\text{m}$.

[3.5 marks]

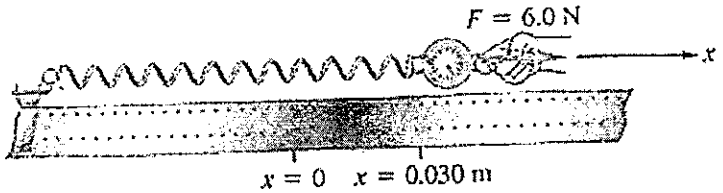

Figure 5(a)

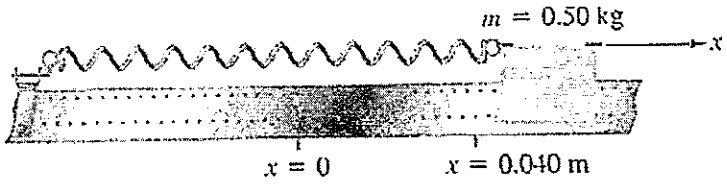

Figure 5(b)

Continued...

APPENDIXES

LIST OF PHYSICAL CONSTANTS

Electron mass,	m_e	=	9.11×10^{-31} kg
Proton mass,	m_p	=	1.67×10^{-27} kg
Neutron mass,	m_n	=	1.67×10^{-27} kg
Magnitude of the electron charge,	e	=	1.602×10^{-19} C
Universal gravitational constant,	G	=	6.67×10^{-11} N.m^{2}kg^{-2}
Universal gas constant,	R	=	8.314 J/K.mol
Hydrogen ground state,	E_o	=	13.6 eV
Boltzmann's constant,	k_B	=	1.38×10^{-23} J/K
Compton wavelength,	λ_c	=	2.426×10^{-12} m
Planck's constant,	h	=	6.63×10^{-34} J.s
		=	4.14×10^{-15} eV.s
Speed of light in vacuum,	c	=	3.0×10^8 m/s
Rydberg constant,	R_H	=	1.097×10^7 m^{-1}
Acceleration due to gravity,	g	=	9.81 m s^{-2}
1unified atomic mass unit,	1 u	=	931.5 MeV/c^2
		=	1.66×10^{-27} kg
1 electron volt,	1 eV	=	1.60×10^{-19} J
Avogadro's number,	N_A	=	6.023×10^{23} mol^{-1}
Threshold of intensity of hearing,	I_o	=	1.0×10^{-12} W m^{-2}
Coulomb constant,	$k = \frac{1}{4\pi\varepsilon_o}$	=	9.0×10^9 Nm^2 C^{-2}
Permittivity of free space,	ε_o	=	8.85×10^{-12} C^2/N.m^{-2}
Permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ (T.m)/A
1 atmosphere pressure,	1 atm	=	1.0×10^5 N/m^2
			1.0×10^5 Pa
Earth: Mass,	M_E	=	5.97×10^{24} kg
Radius (mean),	R_E	=	6.38×10^3 km
Moon: Mass,	M_M	=	7.35×10^{22} kg
Radius (mean),	R_M	=	1.74×10^3 km
Sun: Mass,	M_S	=	1.99×10^{30} kg
Radius (mean),	R_S	=	6.96×10^5 km
Earth-Sun distance (mean),		=	149.6×10^6 km
Earth-Moon distance (mean),		=	384×10^3 km

Continued...

LIST OF FORMULA

Differential Rule

$$y = kx^n$$

$$\frac{dy}{dx} = knx^{n-1}$$

Trigonometric Identity

$$\sin\theta = \frac{opposite}{hypotenuse} \qquad \cos\theta = \frac{adjacent}{hypotenuse}$$

$$\tan\theta = \frac{opposite}{adjacent}$$

$$\sin\alpha + \sin\beta = 2\cos\left(\frac{\alpha-\beta}{2}\right)\sin\left(\frac{\alpha+\beta}{2}\right)$$

$$\sin(\alpha-\beta) + \sin(\alpha+\beta) = 2\sin\alpha\cos\beta$$

NEWTONIAN MECHANICS

$$v = \frac{\Delta x}{\Delta t} \qquad a = \frac{\Delta v}{\Delta t} \qquad v = u + at \qquad s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as \qquad s = \left(\frac{u+v}{2}\right)t$$

$$W = Fs\cos\theta \qquad W = mg \qquad \sum F = F_{net} = ma$$

$$f = \mu N \qquad p = mv \qquad \sum F = \frac{\Delta p}{\Delta t}$$

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2 \qquad m_1u_1 + m_2u_2 = (m_1 + m_2)v \qquad P = \frac{W}{t} = \frac{E}{t} = \frac{Fd}{t} = F\bar{v}$$

$$K = \frac{1}{2}mv^2 \qquad PE_s = \frac{1}{2}kx^2 \qquad F_s = -kx \qquad PE_G = mgy$$

$$v_{circular} = \frac{2\pi r}{T} \qquad a_c = \frac{v^2}{r} \qquad F_g = G\frac{m_1m_2}{r^2} \qquad U_g = -G\frac{m_1m_2}{r}$$

$$T^2 = K_sr^3 \qquad T_s = 2\pi\sqrt{\frac{m}{k}} \qquad F_c = m\frac{v^2}{r}$$

$$\omega = \sqrt{\frac{k}{m}} \qquad \omega = \sqrt{\frac{g}{l}} \qquad T_p = 2\pi\sqrt{\frac{l}{g}} \qquad T = \frac{2\pi}{\omega} = \frac{1}{f}$$

End of Paper.